The Behaviour of Air Rifle Pellets in Ballistic Gel

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Introduction

Although air weapons are considerably lower in power than other firearms, there is increasing concern that serious injuries can result from their misuse. The present study was therefore carried out to improve understanding of the terminal ballistic behaviour of air rifle pellets. Pellets were fired into ballistic gel under a variety of conditions, and the pellets penetrated further than anticipated from their low cross sectional density. Test firings were also carried out firing pellets into ballistic gel that contained sections of animal bone. Computed tomography (CT) and visual observation were employed to record the interactions.

Background

Extensive research has been conducted on various aspects of firearms, but much less work has been carried out into air weapons. The public perception is that airguns are less hazardous because the projectile has much lower energy: However, most firearms offences within the UK are by air weapons. The majority of these are lesser offences such as vandalism, and minor assault but a number of incidents occur with serious or fatal outcomes. This study was therefore carried out to develop understanding of the behaviour of air pellets.

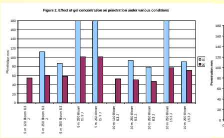
Fig 1. Pellet tracks in gel contained in a knife holder

Experimental Method

Details of the study are given in reference [1]. Four air rifles were used to deliver different power and various variables were examined. In another phase of the study a section from a cow femur was placed in the gel with one face at a predetermined depth and angle to the line of firing. After firing the gel was photographed before the pellets were removed. For 15 of the bone samples, the specimen was taken for examination by computed tomography (CT) scanning before removing the pellets from the gel. CT scanning uses x-rays to take a series of 2-D image 'slices' through the object and these are combined by computer to produce a 3-D image.

Behaviour of Pellets in Ballistic Gel

Most authors use a 10% gel but in the present study this did not give the expected stopping distances. Based on Jussila's work [2] it had been anticipated that pellets would come to rest within 80 mm, but pellets penetrated further and rebounded off the plastic base of the knife holder (figure 1). A detailed study was therefore carried out of gel properties and their effect on air pellet behaviour. The effect of variables such as Bloom strength, gel concentration, firing distance, air rifle power, and pellet shape were all examined and the effect of these variables were as expected. Figures 2 and 3 indicate the effect of gel concentration, power and range on penetration.



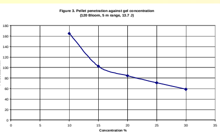


Fig 2. Penetration Fig 3. Effect of concentration

CT Scanning of Bone in Gel

CT scanning showed potential as a tool for examining pellet damage. The bone appeared to be undamaged, and showed no evidence of density change due to compaction, although some scans may show evidence of 'wipe' of lead from the pellet. The pellets were severely deformed on impact. If the pellet strikes the bone at an angle, less energy is absorbed by the impact and the pellet fragments can ricochet and cause further damage.

One advantage of CT scanning is the ability to differentiate different materials and to filter out the bone, thus allowing examination of the pellets in situ by rotating the image in 3 dimensions. Figures 4 and 5 present 2-D images to demonstrate this.

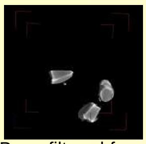


Fig 4 Bone & pellet Fig 5 Bone filtered from scan

Interaction of Pellet with Bone

The length of the pellet tracks in the gel were measured, and the dimensions of the pellet fragments were recorded. As expected, the deeper the bone is mounted in the gelatin, the less damage is caused to the pellet. It would be expected that a deeper depth of gelatin would slow down the pellet and absorb the energy from the pellets, resulting in lower impact energy. Most damage to the pellet occurs with the smaller angles (direct impact) rather than the larger angles (oblique impact) where the pellet is deflected. Consequently, the distance travelled after impact depends on the angle of incidence.

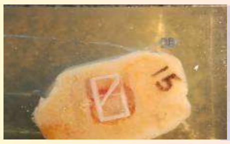


Fig 6 Impact of pellet. Fig 7 Pellet damage

When a pellet approaches the corner or edge of the bone in a straight line, it sometimes seems to curve in towards the bone at a distance of about 5mm from the bone, as seen in figure 6. The cause is unknown, but may be due to the gel being less elastic due to the nearby presence of the bone.

Energy on Impact

Estimates of the energy losses for each part of the pellet flight were made in order to determine the energy loss on impact with the bone. It was assumed that the pellet experienced a constant retarding force from the gel as the gel yielded, but further studies are required to confirm this and to examine the effect of the impulse at phase boundaries.

Conclusions.

Air rifle pellet penetration in ballistic gel under various conditions has been examined, and CT scanning has been used to examine the impact on bone. The disipation of energy during impact has been discussed.

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References

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